Passive Acoustic Survey of Cetacean Abundance Levels (PASCAL)
End-of-Cruise Report: August 19 – September 30, 2016

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Background

SWFSC conducted a dedicated acoustic survey for cetaceans throughout the California Current off the U.S. West Coast in August and September 2016. The survey was called PASCAL: Passive Acoustic Survey of Cetacean Abundance Levels. It was conducted from the NOAA Ship *Bell M. Shimada* (hereafter just "*Shimada*"), which is quieter vessel than the older vessels used in previous large scale cetacean and ecosystem assessment surveys.

Focal study species were beaked whales (family Ziphiidae), sperm whales (*Physeter macrocephalus*), and dwarf and pygmy sperm whales (genus *Kogia*). Due to their cryptic behavior, these species are difficult to survey visually. Consequently, population abundance estimates from visual line-transect data, collected during past large-scale cetacean assessment surveys, have poor precision. In the case of beaked whales from the genus *Mesoplodon*, existing estimates are not even resolved to species. Following recent advancements in methodology (Griffiths and Barlow 2015; Griffiths and Barlow 2016), the primary objective for PASCAL was to conduct a large scale acoustic survey to obtain improved data for estimating population size for these species throughout the California Current study area off the U.S. West Coast.

A secondary objective was to improve our ability to identify acoustic calls to the species level. For example, many beaked whale detections are identifiable to the genus level (e.g., *Mesoplodon*), but we lack paired visual sighting confirmation to allow species-specific *Mesoplodon* calls to be identified to the correct species. Once calls are identified to the species level, we will be able to provide species-specific density estimates in the California Current for the first time.

A third objective materialized during the PASCAL cruise. We conducted a pilot experiment, consisting of paired deployments of acoustic instruments over seamounts and in nearby areas off the seamounts, to explore the hypothesis that beak whale occurrence is associated with these topographic seafloor features.

The cruise was divided into three legs: Leg 1 (Aug 19 – 23), Leg 2 (Aug 23 – Sept 7), and Leg 3 (Sept 11 – Sept 30). The legs were led by Shannon Rankin, Jeff Moore, and Jay Barlow, respectively (all from SWFSC). The first leg was a transit leg (from the *Shimada's* home port in Newport, Oregon, to San Diego, California), during which scientist Rankin deployed 5 acoustic devices referred to as DASBRs (these are described in the next section). Scientific crew on Legs 2 and 3 consisted of the cruise leader, a lead acoustician and acoustic technician, two dedicated visual observers, and two visiting scientists to assist with various operations (see Acknowledgments).

DASBR Survey Effort

1. Abundance Estimation

The primary data collection instrument was a sparse network of Drifting Acoustic Spar Buoy Recorders (DASBRs), deployed at pre-determined locations distributed approximately uniformly throughout the California Current study area offshore of the continental shelf (Fig. 1). Each DASBR (Fig. 2) includes a pair of hydrophones, vertically separated by 10 m, with the midpoint positioned at approximately 100 m depth. Acoustic signals received by the hydrophones are recorded on an *in situ* data recorder (a few different types used; see Table 1). The hydrophones and recorder are attached to a line that originates from a vertical spar buoy at the surface and terminates at depth with an anchor (to maintain verticality and positional stability of the hydrophones in the water column). A 30-m elastic cord at the top of the line helped isolate the hydrophones from wave motion.

The three types of recording devices used in the DASBRs had different battery and memory capabilities and different maximum sampling rates. Duty cycles were selected to match the capabilities and expected deployment durations for each instrument. Eleven Soundtrap ST-4300 recorders were set to record for 2 minutes out of every 10 min at 288 kHz sampling rate. Four Wildlife Acoustics SM2+Bat recorders were set to record for 2 minutes out of every 4 min at a 192 kHz sampling rate. Four Wildlife Acoustics SM3M recorders were set to record continuously, with each hour consisting of 29 2-minute files at a 256 kHz sampling rate followed by one 2-minute file at 96 kHz sampling rate (for cleaner ocean noise measurements). All devices recorded stereo signals from two hydrophones. Hydrophone types, sensitivities and other relevant settings are given in Table 2.

A pressure and 3-D accelerometer logger (Loggerhead Computers Open Tag) was included in some deployments to measure hydrophone depth and array tilt (Table 1). Array depth is critical for estimating range to the vocalizing animals, and array tilt is critical because different (and less precise) methods are required for range estimation if the array is not vertical in the water column. Hydrophone depths for SM2+Bat recorders were logged using a separate pressure sensor using the SM2's 12-bit data logger.

An additional single-channel acoustic recorder (Soundtrap 300HF) was included experimentally for some deployments. At station 9, an experiment was conducted to determine whether the automated click detection algorithm in a ST300HF can reliably detect beaked whale clicks and their surface reflections. An ST300HF with an external battery pack was attached between the two other hydrophones and was set to record continuously at 48 kHz and to record click events at 576 kHz. If successful, click detection algorithms could reduce data storage requirements and allow collection of more continuous data for a longer period of time. At stations 26 and 29, another experiment was conducted with an ST300HF recording continuously at 288 kHz at a depth of 150 m below the bottom of the array. These data will be used to determine whether surface reflections that are recorded at 100 m depth are also detectable at 250 m depth.

A total of 21 DASBRs were deployed as part of the primary acoustic survey design for estimating population size of the target species (Fig. 1). Five DASBRs were deployed during Leg 1 (Deployments 1-5) and 16 during Leg 2. One of the DASBRs deployed on Leg 1 (Deployment 4) did not drift as expected and thus was did not sample a variety of habitats. It was retrieved at the end of Leg 2 and another DASBR was re-deployed to replace it at a nearby location (DASBR 21). Collectively, these 21 primary DASBRs were at sea for a total of 373 days. Individual DASBRS were at sea from between 11 and 23 days (Table 3) and one drifted ~200 nmi during that time period. In total, there were 388 days of total recording effort (including the ad-hoc seamount study).

2. Ad hoc Seamount Experiment

No significant time was lost on the cruise due to weather or mechanical problems, which allowed additional time in the schedule for a focused study of cetaceans on and near seamounts. Beaked whale are commonly believed to be concentrated on such bathymetric features. To evaluate this hypothesis, nine DASBRs were re-deployed on or near San Juan Seamount and Rodriguez Seamount (Deployments 22-30 at the ends of Legs 2 & 3) (see Inset in Figure 1). All DASBR deployments are detailed in Table 1.

A preliminary look at the acoustic data indicates that high-quality acoustic data was obtained for 28 of the 30 deployments (Table 1). One deployment (of a Wildlife Acoustics SM2+Bat recorder) appears to have failed completely (Deployment 14) due to excessive noise from one of the hydrophones or pre-amplifiers. Another deployment (also a Wildlife Acoustics SM2+Bat recorder) was noisy below 20 kHz but should be fine for beaked whales and *Kogia*. In addition, two deployments of the ST43000 recorders ended prematurely due to a bug in their systems that resulted a failure in their duty cycle (filling up available memory too fast) but recorded high-quality data.

<u>Towed acoustic array effort</u>

During transit between DASBR deployments and retrievals, we conducted dedicated towed hydrophone array work for the purposes of (a) providing information to estimate the depth profile of acoustic recordings, which are needed to estimate the horizontal range of DASBR detections (for density estimation) and (b) provide visual confirmation of the species identification associated with different beaked whale call types within the genus *Mesoplodon*. Due to time and personnel constraints, hydrophone arrays were not towed during Leg 1.

On most days during PASCAL, we towed two different hydrophone arrays, mainly during daylight hours. At the beginning of Leg 2, a 4-element spatial array was towed. This prototype designed by Proteus Technologies allowed better localization capabilities but was determined to be too noisy. It was replaced by a series of two 2-element oil-filled linear hydrophone arrays (IL15s and EA15e) separated by 20m from 8/31 to 9/14. The array depth sensor was not working in that configuration, so only array EA15e was used for the remainder of the cruise. The hydrophone spacing for both linear arrays was 1.0 m. All arrays were towed approximately 300 m behind the ship. The arrays were not towed during rough seas and during some nights.

Basic surface oceanographic data – temperature and salinity – were collected by the *Shimada* during all transiting.

<u>Future analyses of acoustic survey data</u>

During the coming months, two acoustic technicians will be using PamGuard software to review all recordings and find signals from beaked whales, sperm whales, and dwarf & pygmy sperm whales (*Kogia* spp.). The acoustic detections of these species will be analyzed in detail to provide estimates of detection range. These ranges will be used within a point-sampling framework (a version of distance sampling) to estimate the density of these species in the immediate vicinity of the DASBRs. The systematic survey design will then allow us to extrapolate those densities to estimate the abundance of these species in the entire study area.

Data from the seamount experiment will be used to ask whether beaked whale acoustic detection rates are significantly higher on San Juan and Rodriquez Seamounts than in adjacent waters.

<u>Visual observations and biopsy sampling of marine mammals</u>

The main objectives of visual operations were to opportunistically sight and identify target species matched to concurrent acoustic towed array detections; and to opportunistically detect cetacean groups (target species and others) of interest for biopsy sampling. In good weather conditions (e.g., Beaufort state 0 – 2), a pair of observers searched visually for marine mammals using a combination of naked eye, hand-held binoculars, and through 10x25 “big-eye” binoculars mounted on the flying bridge of the *Shimada*. In poorer conditions, and on most days, a single observer was usually on watch during daylight hours. We did not adhere to a systematic visual survey design or observation protocol, as the cruise was not designed for this purpose. Ultimately, only six biopsy samples were collected via crossbow dart from the bow of the *Shimada*: one from short-beaked common dolphin (*Delphinus delphis*) and five from Pacific white-sided dolphins (*Lagenorhynchus obliquidens*).

The number of marine mammal groups sighted during PASCAL were:

CODE	SPECIES	TOT#
005	*Delphinus* sp.	10
013	*Stenella coeruleoalba*	9
017	*Delphinus delphis*	23
018	*Tursiops truncatus*	2
021	*Grampus griseus*	2
022	*Lagenorhynchus obliquidens*	2
027	*Lissodelphis borealis*	1
044	*Phocoenoides dalli*	11
046	*Physeter macrocephalus*	5
049	Ziphiid whale	1
051	*Mesoplodon* sp.	2
061	*Ziphius cavirostris*	4
063	*Berardius bairdii*	2
070	*Balaenoptera* sp.	3
071	*Balaenoptera acutorostrata*	6
074	*Balaenoptera physalus*	4
075	*Balaenoptera musculus*	20
076	*Megaptera novaeangliae*	5
077	Unid. dolphin	10
078	Unid. small whale	1
079	Unid. large whale	4
080	*Kogia* sp.	1
096	Unid. cetacean	5
097	Unid. object	2
	TOTAL	136

Literature Cited

Griffiths ET, Barlow J. 2015. Equipment performance report for the drifting acoustic spar buoy recorder (DASBR). NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-543.

Griffiths ET, Barlow J. 2016. Cetacean acoustic detections from free-floating vertical hydrophone arrays in the southern California Current. The Journal of the Acoustical Society of America, 140(5), EL399-EL404.

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